Some Notes about the Determination of Current Account Equilibrium Real Exchange Rate and the Relation Between Real Exchange Rate and Productive Specialization♣

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The objective of these notes is to present a simple mathematical model of the determination of current account real exchange rate as defined by Bresser-Pereira (2010); i.e. ***the real exchange rate that guarantees the inter temporal equilibrium of balance of payments*** and to show the relation between Real Exchange rate and Productive Specialization at theoretical and empirical level.

1) **Current Account Equilibrium Real Exchange Rate: a mathematical model**.

In order to do so, we will consider a small open economy that produced a homogenous good, tradable in international markets, which can be used for consumption or investment purposes. This homogenous good is supposed to be imperfect substitute of the goods produce abroad in such way that the so called law of one price is not valid. Since the economy produce just one type of good, at the same time homogenous and tradable, real exchange rate can not be defined as the ratio between the price of tradable goods to non-tradable goods; but as the ratio between

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the price of goods produced abroad, denominated in domestic currency, relative to the price of domestic goods, denominated in their own currency. Finally, we will suppose that the economy in consideration has a net foreign liability in the form of net external debt, which generates a flow of net income transferred to abroad.

The current account deficit measured in domestic currency for the economy in consideration is given by:

$$EP^{*}M - PX \; + i^{*}B^{*}E = CAD \qquad (1)$$

Where: E is the nominal exchange rate, P* is the price of the homogenous good produced by the "rest of the world" denominated in foreign currency, M is the quantum of imports, P is the price of the homogenous good produced in the domestic economy denominated in its own currency, i* is the international rate of interest, X is the quantum of exports, B* is the net external debt denominated in foreign currency, CAD is the current account deficit.

Dividing expression (1) by PY; we get[1]:

$$\frac{EP^{*}}{P}\frac{M}{Y} - \frac{X}{Y} \; + \frac{i^{*}B^{*}}{Y}\frac{E}{P} = \frac{CAD}{PY} \; (2)$$

The first term in the left hand part of expression (2) is the trade deficit and the second term is the net income transferred to abroad.

Given that, let us define:

$\frac{B^{*}E}{PY} = b$ as the ratio of external debt to GDP (3a)

$\frac{CAD}{PY} = d$ as the current account deficit as a ratio to GDP (3b)

$\frac{EP^{*}}{P} = e$ as the real effective exchange rate (3c)

Trade deficit as a ratio to GDP could be determined by the following expression:

$$td = \frac{EP^{*}}{P}\frac{M}{Y} - \frac{X}{Y} = \tau_{0}e^{-\tau_{1}}Y^{\tau_{2}}Y^{*-\tau_{3}} \; (3d)$$

Where: τ_0 is s positive constant, τ_1 is the elasticity of trade balance (as a ratio to GDP) relative to real exchange rate, τ_2 is the elasticity of trade balance relative to domestic

[1] Where: Y is the real GDP.

income, τ_3 is the elasticity of trade balance relative to the income of the rest of the world.

Substituting (3a)-(3d) in (2), we get:

$$\tau_0 e^{-\tau_1} Y^{\tau_2} Y^{*-\tau_3} + i^* b = d \quad (4)$$

Defining $h = \frac{Y}{Y^*}$ as the income gap between the domestic economy and the "rest of the world"[1], we can re-write equation (4) in the following way:

$$\tau_0 e^{-\tau_1} h^{\tau_2} Y^{*-(\tau_2+\tau_3)} = d - i^* b \quad (5)$$

Solving equation (5) for *e*, we get the following expression:

$$e = \frac{\tau_0 h^{\tau_2} Y^{*-(\tau_2+\tau_3)}}{d - i^* b}^{\frac{1}{\tau_1}} \quad (6)$$

The usual requirement for the inter-temporal equilibrium of balance of payments establishes that net external debt as a ratio of GDP should kept constant through time, i.e. external debt must not follow and explosive path. This is a necessary but not sufficient condition to guarantee the inter-temporal equilibrium of external accounts. Due to the imperfections in international financial markets, there must exist a maximum limit to the external debt (as a ratio to GDP) that a small open economy is capable to have. This means that inter-temporal equilibrium of balance of payments requires that, in the long-run, external debt as a ratio to GDP must be kept at low and stable levels.

To evaluate the dynamics of external debt as a ratio to GDP, we will take the time derivative of expression (3a). We get:

$$b = \frac{B^*E\ PY - PY\ B^*E}{PY\ ^2} \quad (7)$$

We know that the change in external debt measured in domestic currency is equal, by definition, to the current account deficit, that is $EB^* = CAD$. We will also suppose that in the economy under consideration is valid the perfect capital mobility

[1] We are assuming that h<1

in the sense of Mundell, so that the uncovered interest rate parity holds (Blanchard, 1999, pp.253-255). This means that the dynamics of nominal interest rate is given by[2]:

$$E \approx i - i^* - \rho \quad (8)$$

Where: i is the domestic interest rate, i* is the international rate of interest, ρ is the country risk premium.

In this context, we have:

$$b = d + \quad i - i^* - \rho \quad - \pi - g \ b \qquad (9)$$

Where: g is the growth rate of real GDP and π is the inflation rate.

In steady-state the external debt as a ratio to GDP must be kept constant through time, that is: $b = 0$. This means that the value of external debt as a ratio to GDP for which this variable is constant is given by:

$$b^{ss} = \frac{d}{g+\pi- \ i-i^*-\rho} \quad (10)$$

In expression (10) we verify that the external debt as a ratio to GDP in steady-state is negative function of the growth rate of nominal GDP and a positive function of the interest rate differential (adjusted to rink).

Consider now the existence of a maximum limit for the external debt (as a ratio to GDP), being such limit given by $b^{max} = b$. This means that equation (10) can be used to calculate the level of current account deficit that is compatible with the inter-temporal equilibrium of balance of payments. We get:

$$d = \ g + \pi - (i - i^* - \rho) \ b \ (11)$$

Putting (11) in (6), we get:

$$e = \ \frac{\tau_0 h^{\tau_2} Y^{*-(\tau_2+\tau_3)}}{[g+\pi- \ i-\rho \ ]b}^{\frac{1}{\tau_1}} \ (12)$$

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[2] We must take into account that his result is an equilibrium condition for an economy with perfect capital mobility. In fact, under these conditions, assets denominated in different currencies must have the same rate of return (adjusted to risk) If the rate of interest of the domestic asset increase, than economic agents will hold the same proportion of their wealth in domestic and foreign assets if they anticipate a devaluation of nominal exchange rate.

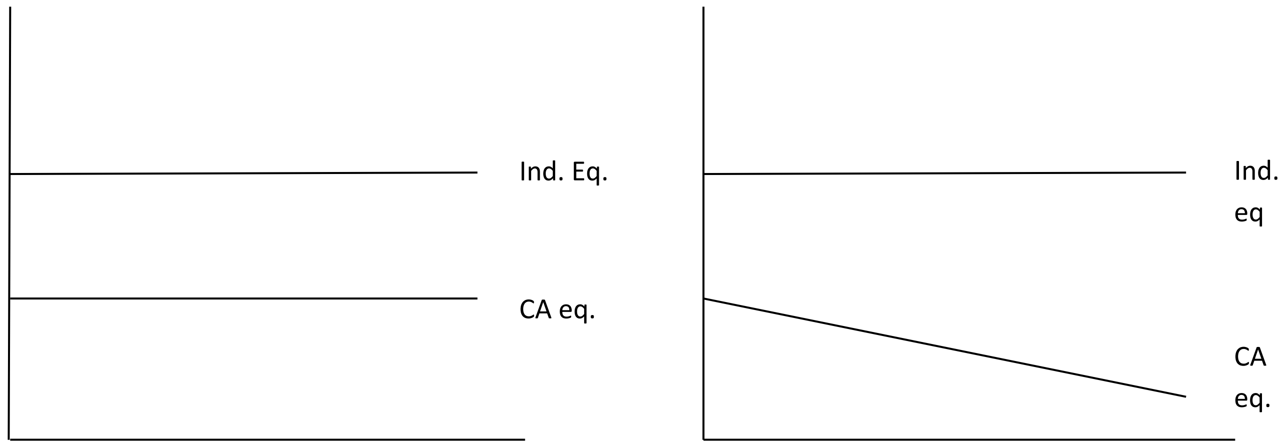
Equation (12) presents the real exchange rate that is compatible with the inter-temporal equilibrium of the balance of payments, that is, the level of real exchange rate that generates a current account deficit that is sustainable in the long term. In other words, it is the real exchange rate that is compatible with a low and stable level of net external debt as a ratio to GDP.

As we can see in equation (12), the current account equilibrium real exchange rate is a function of the gap between the domestic and “the rest of the world” levels of income, the size of the “rest of the world” level of income, the rate of growth of nominal GDP, the domestic rate of interest, the country risk premium and the maximum value of external debt as a ratio to GDP.

Some additional comments about equation (12) are noteworthy. First of all, the equilibrium real Exchange rate is a positive function of h, meaning that lesser the gap between the domestic and foreign economies (closer is h to 1), more devaluated must be the equilibrium real exchange rate. This means that for those countries whose economy is growing below the world average must face a continuous process of equilibrium real exchange rate appreciation.

In second place, the relation between the size of the economy of the “rest of the world” and the current account equilibrium real exchange rate is negative. This means that the continuous growth of the world economy will produce a cumulative appreciation of current account equilibrium real exchange rate. This effect clearly shows that current account equilibrium real exchange is not constant as supposed by Bresser-Pereira (2010), but decreasing over time. So the magnitude of “Dutch Disease” problem can increase over time, worsening the competitive conditions of domestic industries and accelerating the process of de-industrialization.

Figure 1: *Dutch Disease special* and *general* case.



Dutch Disease: Bresser-Pereira special case

Dutch Disease: General Case

Finally, we can see that equilibrium real exchange rate is a positive function of domestic rate of interest. This means that a monetary contraction, expressed by an increase in the level of domestic interest rate, will result in a increase in the value of real exchange rate that is compatible with the inter-temporal equilibrium of balance of payments. This result can be explained by the fact that an increase in the domestic rate of interest is compatible with the portfolio equilibrium in a perfect capital mobility setting if is followed by an increase in the rate of depreciation of nominal exchange rate. This depreciation will increase the value of external debt as a ratio to GDP. In this setting, the inter-temporal solvency of the balance of payments requires a devaluation of real Exchange rate in order to reduce the current account deficit as a ratio to GDP to a level compatible with the external equilibrium.

2) **Real Exchange rate and Productive Specialization: a Ricardian Model**.

Proposition: in the long run there is no such a thing as a balance of payments constraint if real exchange rate is on the “right” level.

Income elasticities of imports and exports, which are taken as given in the Thirwall (1979) balance of payments growth model, are endogenous variables in the long run, being dependent of productive structure and real exchange rate.

Our starting point will be a reformulation of the Ricardian model of international trade proposed by Dornbusch, Fischer and Samuelson (1977).

Let us consider a world economy composed of two countries (A and B). The only input used in production is labor and there is a *continuum* Z of commodities defined in the closed interval [0,1]. These commodities can be classified in a decreasing order of comparative advantage by means of the ranking of the labor requirement for production of each commodity in both economies. We will assume that:

$$\frac{a_1^*}{a_1} > \frac{a_2^*}{a_2} > \ldots > \frac{a_n^*}{a_n} > \ldots \qquad (13)$$

Where: a_1^* is the labor requirement for production of commodity 1 in country B and a_1 is the labor requirement for production of commodity 1 um country A.

Let $A(Z) = \frac{a^*(Z)}{a(Z)}$ the relative productivity of labor employed in the production of commodity Z. We will assume that: $A'(Z) < 0$.

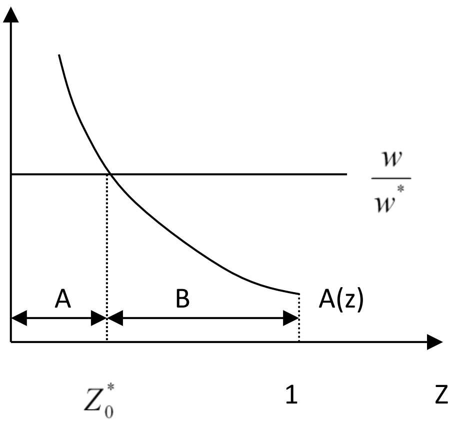
The international specialization of each commodity in country A or B will depend on the structure of relative wages. Commodity Z will be produced in country A if and only if the following condition was met:

$$a(z)w < a^*(z)w^* \quad \Leftrightarrow \quad \frac{a^*(z)}{a(z)} > \frac{w}{w^*} \qquad (14)$$

Where: w^* is the real wage that prevails in economy B; *w* is the real wage that prevails in economy A.

The determination of the level of international specialization can be visualized y means of figure 2 below:

Figure 2: Determination of the level of international specialization



In the modified version of the Ricardian model by Dornbusch *et alli* (1977), the structure of relative wages was determined by the *market-clearing* in the labor market. In the version presented here we will assume that real wage is determined by a bargaining process between firms and labor unions, and that there is an inverse relation between the level of the real wage in a country and the real exchange rate. So, the real wage paid in economy A can be expressed by:

$$w = f(q) \quad ; f' < 0 \quad (15)$$

Where: q is the real exchange rate.

In a world economy composed of only two countries, a real exchange rate appreciation in one country means real exchange rate depreciation in the other country. If the real exchange rate appreciates in country A, real wage must increase in this economy. The other side of this story will be a exchange rate depreciation in country B and a reduction in real wage in this country. So a real exchange rate appreciation in country A will displace the structure of relative wages upward in figure 5.1, reducing the number of commodities produced in country A and increasing the number of commodities produced in country B. From this reasoning we can conclude that a real exchange rate appreciation in country A will produce an increase in the level of productive specialization of this economy.

What are the effects of an increase in the level of productive specialization of economy A over its long-run growth rate? As shown by Dosi, Pavitt e Soete (1990, ch.7) an increase in the level of productive specialization of an economy will increase the marginal propensity to import of this economy, decreasing the value of exports multiplier. This reduction of exports multiplier will cause a reduction in the long-run equilibrium value of output growth.

From this reasoning, we can conclude that the level of real exchange rate have a lasting effect over the growth rate of capitalist economies, since real exchange rate is one of the determinants of the degree of productive specialization, which determines the marginal propensity to import and the exports multiplier.

As a final conclusion of this reasoning, we can say that real exchange rate can affect the growth rate of capitalist economies by other channels than its direct impact over the level of exports and imports. Real exchange rate has not only a static effect over these variables, but also a dynamic impact, influencing the growth rate of exports and imports. The literature about exchange-rate and growth emphasizes the *static effects* of real exchange rate changes over the level of current account balance by means of the estimations of price-elasticity of demand for exports and imports. These empirical studies show that price-elasticies are low; so that changes in the level of real exchange rate are supposed to have almost no effect over growth rates in a demand-led growth regime. In the words of McCombie and Roberts:

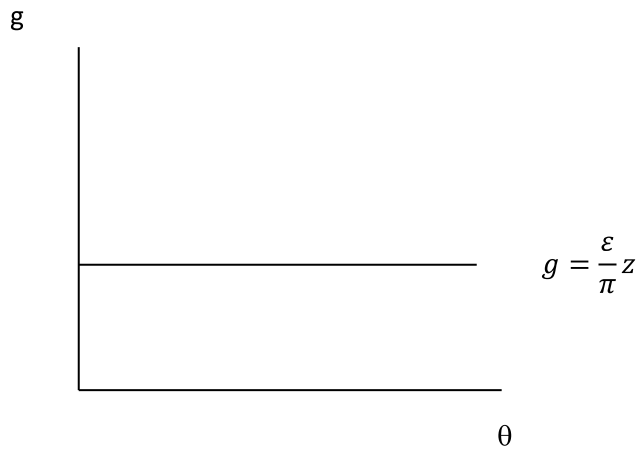
> "*There are numerous studies estimating import and export demand functions as part of a test of Thirwall's law, and these generally report estimated price elasticities that are either statistically insignificant, low or have a priori unexpected signs*" (2002, p.92).

These studies, however, do not take in consideration the impact of changes in the real exchange-rate over income elasticities of demand for exports and imports. But this channel seems to be the way by which exchange-rate policy can affect the long-run growth rates of capitalist economies.

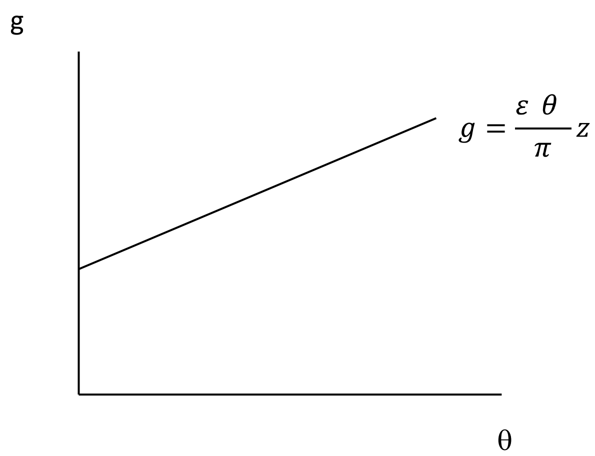
In the terms of Thirwall´s growth model, we can state that balance of payments equilibrium growth rate is given by:

$$g = \frac{\varepsilon(\theta)}{\pi} z$$

Figure 3 – Exchange rate and Thirwall Model



Thirwall Model



Modified Thirwall Model

3) An empirical analysis of the Relation between Real Exchange Rate and Income Elasticity of Exports.

The long-run export growth rate of a country or region is determined by the product between the *world income elasticity of exports* and the income growth rate from the rest of the world divided by the *domestic income elasticity of imports*. The income elasticity of exports captures the influence of extra-price factors - such as the technological content of exported products, the degree of differentiation of exported products compared to its competitors in the international market, the value added to these products and so on - on the external competitiveness of a country. Thus, the greater the income elasticity of exports, the greater the export growth rate of a country for the same rest of the world income growth rate.

Generally, the countries that compose the so-called "technological frontier" should have a greater income elasticity of their exports in relation to less developed countries. This is because that the countries which are closer to the "technological frontier" tend to be exporters of products with higher added value and with higher technology than the ones that are distant from it. That way, it is expected that the so-called technological gap is an important determinant of income elasticity of exports and, therefore, of the export growth rate in the long run (Dosi, Pavitt and Soete, 1990, p. 26).

The theoretical and empirical literature about the determinants of income elasticity of exports has, however, neglected the role of real exchange rate as one of the determinants of elasticity. Indeed, the empirical work on the variables that affect exports' performance has been limited to estimating the exports elasticities with respect to variations of the real exchange rate. In this context, the coefficients estimatives of the exports elasticities in relation to the exchange rate have present the opposite sign expected by the theory or have been non-significant (see McCombie and Roberts, 2002, p.92).

No effort has been made to assess the existence of a relationship between the income elasticity of exports and the real exchange rate. The existent literature seems to support the hypothesis that the real exchange rate can only affect the long-run economic growth through the effect that it has on the willingness of domestic and foreign consumers to spend their income on domestic or foreign goods. Thus, the existent literature neglects the impacts that the real exchange rate may have on the *production structure of the economy* and, through them, on the income elasticity of exports.

From a purely theoretical level, we can establish a relationship between the level of real exchange rate and the income elasticity of exports, taking, for example, as a starting point, the Ricardian model of international trade presented by Dornbusch, Fischer and Samuelson (1977). Based on this model, the degree of productive specialization of an economy – in other words, the number of different types of goods produced by the domestic economy - is determined by the ratio between the domestic real wage and real wages paid all over the world.

Thus, the higher the real wages paid in the domestic economy compared to the real wages paid in the rest of the world, the higher the level of productive specialization of the country; in other words, the lower the number of different types of goods produced in the domestic economy The greater its productive specialization, the lower its exports growth resulting from the rest of the world income growth; in other words, the lower the income elasticity of exports.

The real exchange rate affects the degree of productive specialization of the economy as it has a direct impact on real wages. Thus, an appreciation of real exchange rate, as a rule, causes an increase in real wages, thereby increasing the cost of production in the country relatively to the cost of production in the world. This process induces the migration of production activities that were performed in the domestic economy to the outside, causing a *deindustrialization* of the domestic economy, which has adverse effects on its export capacity.

To assess whether the income elasticity of exports is affected by the real exchange rate and the technological gap, we will investigate 30 developed and developing countries[3] using the methodology of *time series* (first stage) and *cross-country* (second stage). We will use a regression process in two stages: (i) we estimate the values of the selected countries' income elasticities of exports in the period 1995 – 2005; and (ii) we estimate the response of the income elasticity of exports of a country against the fluctuations in the real exchange rate and in the technological gap.

The equation estimated in the first stage is as follows:

[3] Austria, Germany, Malaysia, South Africa, France, Holland, Chile, Sweden, Turkey, Denmark, New Zealand, Canada, Australia, Portugal, Switzerland, Spain, United States, Mexico, Brazil, Hungary, Italy, Argentina, Indonesia, UK, Norway, Thailand, Korea, Czech Republic and Russia.

$$X_i = c_0 + c_1 Q + c_2 Y^* + \varepsilon_i \qquad (16)$$

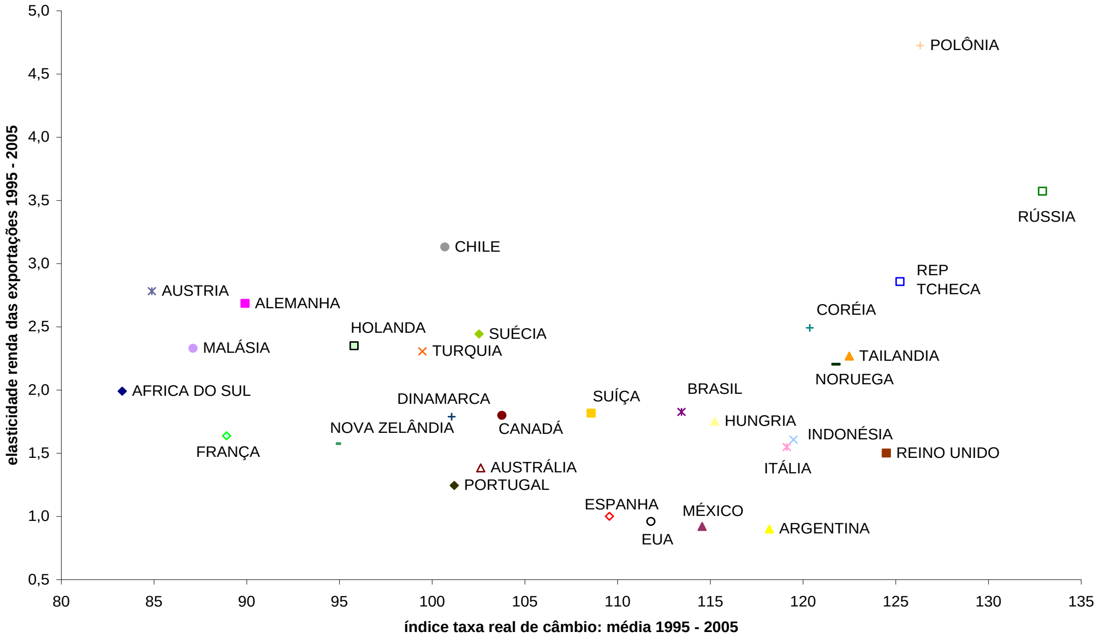
where X_i is the real value in dollars of country i*'s* exports, Y^* is the real value in dollars of the rest of the world's GDP, *Q* is an index of real exchange rate (1995 = 100), c_o is a constant, ε_i is the error term, c_1 represents exchange rate elasticity of exports, c_2 represents income elasticity of exports, in other words, the response of each country's exports to changes in the the world GDP[4]. All series are quarterly data.

The equation in the second stage was estimated to capture the effects, if any, of real exchange rate and technological gap on the income elasticity of exports. To reach this goal we estimated eight different equations to choose the one that best fits the data. All variables were transformed into natural logarithms prior to the estimations.

The real exchange rate was obtained using quarterly data of nominal exchange rate and consumer price index obtained from the *International Financial Statistics*, IFS, and normalized to 100 in 1995. Figure 1 below shows the dispersion of income elasticity of exports and real exchange rate index.

[4] From the 30 countries reviewed, 24 did not present any problem in the estimation of c_2 in level. For Chile, Denmark, Norway, New Zealand, Portugal and United Kingdom, exports and GDP of the world do not cointegrate, making it impossible to estimate the correct level of the income elasticity of exports. Other two countries, Mexico and Austria, exhibit stationarity of the index of real exchange rate in level.

FIGURE 2 – INCOME ELASTICITY OF EXPORTS VERSUS REAL EXCHANGE RATE



Source: own elaboration from IFS data.

Figure 2 allows us to observe the existence of a nonlinear relationship between income elasticity of exports and real exchange rate across the countries. More precisely, we see that developed countries have a negative relationship between income elasticity of exports and real exchange rate in the period 1995-2005; in other words, developed countries with higher income elasticity of exports usually have a more appreciated real exchange rate than their correlates. In another way, we can verify the existence of a positive relationship between these two variables when we observe developing countries; in other words, developing countries with higher income elasticity of exports have a more devalued real exchange rate. (em algum lugar deve colocar a definição da taxa de câmbio, ou seja, que uma elevação é uma desvalorização)

In order to estimate more precisely the effects of real exchange rate and the technological gap on income elasticity of exports, we have estimated eight specifications and select the one that best fits the data. The tests are presented in Table 9 below.

Model 3 is the one that best fits the data, suggesting that there is a relationship in the form of *U* for the variables income elasticity of exports and real exchange rate index in the period 1995 - 2005.

The interpretation of the descending part of the estimated curve for the exchange rate elasticity comes from the resistance of unions against real wages reductions resulting from a real exchange rate devaluation, thus requiring adjustments of nominal wages to recover the wages level of its members. This phenomenon is known as *real wage resistance* (see McCombie and Roberts, 2002, p.92), and its consequences are that the costs of a real exchange rate devaluation are fully absorbed by companies in the form of lower profit margins.

On the other hand, the interpretation of the ascending part stems from the fact that developing countries have their export mainly based on agricultural and mineral commodities, in which prices are negotiated on the international market and whose costs are composed primarily of non-tradables goods, since they are intensive in unqualified labor. Thus, an exchange rate devaluation generates a higher increase in revenue than in the production cost. Consequently, it brings an increase in profit margins, which allows a greater investment in the exporting sectors productive capacity.. Therefore, export is stimulated through a devaluation of the real exchange rate.

It follows that developing countries may seek to offset the effects of their technological backwardness on international competitiveness through policies that keep their real exchange rate depreciated in relation to developed countries. The maintenance of a depreciated real exchange rate will promote investment in the exporting sector, expanding the economy export capacity and the income elasticity of their exports.

TABLE 9: TESTING TO CHOOSE THE ECONOMETRIC MODEL

	MODELO 1		MODELO 2	
EQUAÇÃO	$\ln ERX = c_1 + c_2 \ln CB$	p-valor	$\ln ERX = c_1 + c_2 \ln CB + c_3 \ln HR$	p-valor
c_1	0,7828	0,7758	1,2942	0,6441
c_2	0,0306	0,9583	-0,1627	0,7873
c_3			-0,1259	0,3257
R^2		0,0000		0,0035
JB		0,9656		0,9111
White		0,1049		0,1846
DW		1,7070		1,7678
	MODELO 3		**MODELO 4**	
EQUAÇÃO	$\ln ERX = c_1 + c_2 \ln CB^2 + c_3 \ln CB$	p-valor	$\ln ERX = c_1 + c_2 \ln CB^2 + c_3 \ln CB + c_4 \ln HR$	p-valor
c_1	258,1090	0,0081	256,6109	0,0157
c_2	11,8989	0,0083	11,8287	0,0162
c_3	-110,7427	0,0082	-110,0947	0,0160
c_4			-0,0049	0,9683
R^2		0,2314		0,2314
JB		0,8954		0,8929
White		0,5708		0,4623
DW		1,5727		1,5753
	MODELO 5		**MODELO 6**	
EQUAÇÃO	$\ln ERX = c_1 + c_2 \ln CB^2 + c_3 \ln CB + c_4 \ln HR^2 + c_5 \ln HR$	p-valor	$\ln ERX = c_1 + c_2 \ln HR$	p-valor
c_1	267,1872	0,0079	0,5401	0,0002
c_2	12,3168	0,013	-0,1183	0,3350
c_3	-114,6664	0,0134		
c_4	-0,2136	0,3363		
c_5	-0,4218	0,35		
R^2		0,2599		0,0332
JB		0,7508		0,8566
White		0,2624		0,2042
DW		1,6103		1,8001
	MODELO 7		**MODELO 8**	
EQUAÇÃO	$\ln ERX = c_1 + c_2 \ln HR^2 + c_3 \ln HR$	p-valor	$\ln ERX = c_1 + c_2 \ln HR^2 + c_3 \ln HR + c_4 \ln CB$	p-valor
c_1	0,9580	0,0418	1,7778	0,5434
c_2	-0,0498	0,7032	-0,0495	0,7101
c_3	-0,5215	0,4065	-0,5387	0,4018
c_4			-0,1736	0,776
R^2		0,0466		0,0496
JB		0,7550		0,8329
White		0,1685		0,2101
DW		1,8250		1,3788

Note: *lnERX* is the the logarithm of the income elasticity of exports, *lnCB* is the logarithm of the real exchange rate and *lnHR* is the logarithm of the *per capita* income gap. The *p-value* indicates in which level of confidence the estimated coefficients are significant. *DW* is the Durbin-Watson test for detection of autocorrelation between residuals. *JB* is the Jarque-Bera test, which checks whether the errors of the estimated equations are normally distributed and the *White* is the White test, which checks the existence of heteroscedasticity. For the proper interpretation of the tests, see Asteriou (2006) and Hamilton (1994).

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